(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 314 287 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **88308584.7**

(51) Int. Cl.4: **H01F 23/00 , H02M 1/14**

(22) Date of filing: **16.09.88**

(30) Priority: **28.10.87 US 114803**

(43) Date of publication of application: **03.05.89 Bulletin 89/18**

(84) Designated Contracting States: **DE FR GB IT**

(71) Applicant: **International Business Machines Corporation**
Old Orchard Road
Armonk, N.Y. 10504(US)

(72) Inventor: **Gillett, John Brian**
7 Meher Circle
Woodstock New York 12498(US)
Inventor: **Spreen, James Harold**
R.D. No.2., Box 52N Cedar Ridge Road
Stone Ridge New York 12484(US)

(74) Representative: **Grant, Iain Murray**
IBM United Kingdom Limited Intellectual Property Department Hursley Park
Winchester Hampshire SO21 2JN(GB)

(54) **Pluggable power system having magnetic flux coupled power transformer and inductive filter components.**

(57) A regulated voltage electrical power system has a driving section and a driven section. The driving section includes a power transformer primary structure and a ripple current carrying, driving winding of a filter system for the smoothed outputs circuits of the power system, each of which includes a single turn, driven filter winding magnetically coupled to the driving winding by a multi-path core structure. Each driven filter winding links that part of the multi-path structure which corresponds in cross-sectional area to the relative ripple voltage imposed by the power transformer on it. The power transformer secondaries for the outputs of the power system are also of a single turn each, differing output voltages being achieved by provision of differing number of primary winding turns associated with the various outputs. Planar diodes and core gap-filling ferrite inserts are provided in the secondary winding structures.

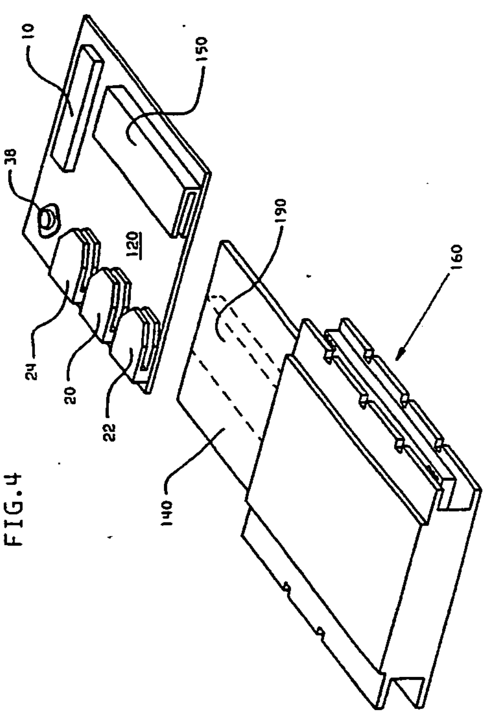


FIG.4

EP 0 314 287 A1

PLUGGABLE POWER SYSTEM HAVING MAGNETIC FLUX COUPLED POWER TRANSFORMER AND INDUCTIVE FILTER COMPONENTS

This invention relates to electrical power systems and more particularly to a power system having improved magnetic and other components which function to transfer power and to provide filtering interrelationships and at the same time act as connectors between halves of the system which are separable for maintenance and other purposes.

Various power and filter systems having relatively movable, magnetically coupled windings have long been known, for both power transfer and filtering purposes. Examples are seen in rotatable secondary winding voltage regulating power transformers, variable coupling filtering devices, and in separable primary and secondary energy coupling devices. Examples of the aforedescribed filter and connector arrangements are seen in US-A-1,490,031 to Schmidt, and an article published in the IBM Technical Disclosure Bulletin, Volume 17, No. 2 (July, 1974), pages 492-493.

Coupled inductor filter systems wherein a plurality of substantially "zero ripple"" outputs can be provided in a transistor switching regulator are also known. Examples are seen in US-A-4,703,409 to J. H. Spreen, one of the inventors herein, and assigned to the assignee of this application.

In large data processing systems, it is customary to provide a "machine frame" which carries power supply and regulating elements for energising circuit cards which are plugged into the machine frame. In such cases, both power and logic signal connectors are engaged as the card is plugged into place. It has also been known to releasably connect the power supply subsystems themselves into the machine, so that such subsystems can be replaced as easily as a logic or memory circuit card might.

There exist, however, needs to optimise such relationships and provide ever denser packaging of the subsystems and card arrays in large data processing systems.

The present invention provides a power system including a separable transformer assembly in which a card having a planar secondary winding of the transformer is detachably mounted thereon to provide power to the card by magnetic coupling without electrical contact, the card being inserted - mechanically but not electrically plugged - into complementary parts of the magnetic circuit of the transformer means, to complete the same.

This provides an improved system and components which enable separation of the system into two portions, one "pluggable" into the other giving a division of primary and secondary elements, and ripple-bearing and ripple-free filter elements, whereby source parts of the system can be carried by the machine and load circuit parts can be carried by pluggable cards, with the main energy coupling between them being magnetic and contactless.

The hereinafter disclosed embodiments include components having particular utility in the aforesaid system, among other uses and can be adaptable to thin configuration so as to be mountable on closely packed circuit cards.

There is disclosed hereinafter a power system which comprises a card having a planar transformer secondary winding mounted thereon to provide power to the card by magnetic coupling without electrical contact, the card being inserted into complementary parts of the magnetic circuit of a power transformer to complete the same. The card carries planar windings magnetically coupled to a filter winding structurally associated with the primary winding of the power transformer.

Also as disclosed, driven filter inductor windings, which can be of one turn each, can be magnetically associated with a driving filter winding by a common magnetic core having a main portion carrying the driving winding and a plural magnetic flux path portion carrying the driven filter windings, with the cross-sectional areas of the paths being so related that single turn windings encircling one or more of the paths can have generated in them, by the flux they encircle, A.C. potentials which although a function of the same a.c. ripple currents carried by the driving winding, differ between themselves in proportion to the differing a.c. ripple potentials imposed on them.

The secondary circuit structures can include planar rectifier and free-wheeling diode components within the respective secondary windings whereby the inductance in the circuit loops of the secondary windings is reduced and the commutating action of the diodes is facilitated.

The primary and secondary portions of the power transformers, and driving and driven portions of the filter inductor optionally can have a lap joint relationship to each other, whereby in each case there is a simplified mechanical interface between the core elements of those portions.

The present invention will be described further by way of example with reference to embodiments thereof as illustrated in the accompanying drawings in which:-

Fig. 1 is a simplified circuit diagram of a multi-level power supply having primary and secondary, and driving and driven, portions which are physically discrete but detachably juxtaposed for magnetic cooperation;

Fig. 2 shows a first subset of the elements of Fig. 1 which form one part of the two part organisation of Fig. 1;

Fig. 3 shows a second subset of elements of Fig. 1 which cooperate in operation with the first subset but are separable therefrom as a discrete subassembly;

Fig. 4 shows one preferred embodiment of the invention in which the portions of core structures carried by the card, powered by the system of the invention, are reduced;

Fig. 5 shows a detail, on an enlarged scale, of portions of the elements shown in Fig. 4, the parts being shown in Figs. 4 and 5 in a card withdrawn state;

Fig. 6 shows the parts shown in 5, but in a connected juxtaposition;

Fig. 7 shows an exploded view of the parts shown schematically in Figs. 5 and 6;

Fig. 8 is a fragmentary circuit diagram showing the electrical relationship of portions of the structure of Fig. 7;

Fig. 9 shows a detail of rectifier chip installation which is positioned as indicated in Fig. 7;

Fig. 10 is an exploded view illustrating the filter inductor structure of Fig. 4;

Fig. 11 shows an electrical and mechanical schematic which corresponds to the practical structure shown in Fig. 10 but is included to illustrate operating principles thereof;

Fig. 12 shows another embodiment of the invention in which the core structures are divided between the machine frame and card elements to engage each other in lapped fashion instead of tongue-and-groove fashion; and

Fig. 13 shows an alternative embodiment of the general subject matter of Fig. 7, but wherein the diodes are positioned differently.

Fig. 1 shows a simplified schematic diagram of a power supply having primary drive circuits 10, a parallel array of primary windings 12, 14, 16, 18, power transformer cores 20, 22, 24, 26, and corresponding secondary windings 28, 30, 32, 34. The primary drive circuits 10 are conventional and a simple example is illustrated to include a D.C. bulk voltage supply 36, a transistor switch 38 in series with the parallel array of primary windings, and oscillator driven pulse width modulation control 40 responsive to a feedback signal on line 42 to vary the ON time of each cycle of operation of the switch 38 so as to maintain the output voltage sensed on line 42 at a desired level with respect to a reference voltage in circuit 40.

A group of the power output windings, in the illustrated embodiment, three of them numbered 28, 30 and 32, are each of a single turn and drive respective output circuits 50, 52, 54, each comprising a rectifier diode 56, 58, 60, an inductor 61, 64, 66, and a free-wheeling diode 68, 70, 72.

The remaining secondary circuit shown, circuit 100, comprises multiturn secondary 34, a rectifier 102, free-wheeling diode 78, a filter inductor 104, and a filter capacitor 106. This circuit 100 provides power to the control circuit 40. The load imposed by the control circuits 40 is such that the current through the filter inductor 104 is continuous, although it has an A.C. ripple component. In accordance with the coupled inductor teachings of US-A-4,703,409, this ripple bearing inductor 104 is magnetically coupled with the other output inductors 62, 64, 66 as indicated at 106 in such manner that current in them is ripple-free. Accordingly, their output circuits 50, 52, 54 need have no output filter capacitors, but small capacitors 110, 112, 114 are provided to smooth less than perfect practical effects, such as slight dimensional imbalancing, switching noise, etc.

The secondary structures 50, 52, 54 are separable from the remainder of the circuit thus far described, resulting in two complementary subset structures, 120 and 140. Fig. 2 shows subset 120 including most of the heavy and bulky elements and Fig. 3 shows the other subset 140. In use, subset 120 might be carried by a machine frame and subset 140 might be part of a circuit card pluggable into the machine frame as will be described.

In one arrangement, the "tongue and groove" structure, most of the core structure 150 linking the inductors 62, 64, 66, and 104 stays with the subset 120, as shown in Fig. 2. This contributes to minimisation of bulk and weight in the other subset 140, Fig. 3.

From the foregoing, it is seen that the organisation of Figs. 1-3 provides a replaceable circuit package, which may be either the base portion 120 or the card portion 140 which can be operated with no conductor-to-conductor mechanical contacts for electrical power connections. Power is supplied to the card 160, Fig. 4, by a link of time-varying magnetic flux.

The functional card 160 incorporates the secondary transformer windings and rectification/filter functions 140 of an appropriate switched-mode power supply/regulator, in addition to the operational circuits normally found on a functional card. Placing the card in its slot in the machine assembles the transformers and an inductor by positioning the secondary windings 28, 30, 32 in the power transformer cores 20, 22, 24, and positioning the

filter inductor windings 62, 64, 66 into the inductor core structure 150.

The planar geometries of the cores and windings are similar to the planar transformers known heretofore in radio frequency apparatus and thus not described in detail. However, the implementation revealed here is unique in that some windings are meant to be withdrawn, as shown for example in Fig. 5. It should be noted that the bulk of the core 20 stays with the portion 120, while only a magnetic gap filter insert 162 moves with portion 140.

During the operation of a forward converter, such as shown schematically in Figure 1, it is necessary to quickly commutate the inductor 62, 64, 66, 104 currents (approximately the respective output currents) from the freewheeling diodes 68, 70, 72, 78 to the secondary windings 28, 30, 32, 34 and rectifying diodes 56, 58, 60, 102. This transfer of current occurs when the switch 38 turns on. A similar commutation of the current from the rectifying diodes back to free-wheeling diodes occurs when the switch 38 turns off. Any inductance in the circuit 164 loop of any secondary winding and diode pair increases these commutate times. Such inductance may be due to actual lead inductance or to the leakage inductance (lack of perfect magnetic coupling) of the respective power transformer. By positioning the diodes 56, 58 inside a planar winding 28, as illustrated in Figure 7, the inductance of this circuit loop can be reduced. In this embodiment, the diodes are implemented as single chip devices, as shown for example in Fig. 9. Further description of this kind of device is given an article entitled "Low Inductance Chip Connector for Power Rectifiers" published in the IBM Technical Disclosure Bulletin, Vol. 29, No. 3 (August, 1986) pages 1071-1072.

Alternatively, the diodes could be implemented as groups of parallel diode pellets. The presence of the primary current in a uniformly spaced spiral primary winding 12 encourages a uniform "sheet" current in the secondary 28. Where parallel groups of diode pellets are used, they would be arranged in a row transverse to the current direction so that there would be equal current sharing among the diode pellets, during commutate times and when the switch 38 is on. The diode chips or pellets can be cooled through a cold plate or heatsink mounted on the rectified DC conductor 170. For simplicity of illustration of the other structure, these cooling features are not shown. They can always be arranged so that the cold plate cools either a ground node or a DC node, so that maximum cooling capability can be obtained without compromising switching behaviour with large capacitances to an electrically grounded heatsink.

The bulk of the filter components on the function card 160 is held to a minimum by using the zero-ripple coupled inductor concepts discussed in US-A-4,703,409. The inductor core 150 and the one winding 140 with ripple are fixed in position; the zero-ripple windings 62, 64, 66 carrying load current are attached to the card. Thus, the secondary portion 140 on functional card connects to the power supply base portion 120 through the magnetic flux links of cores 20, 22, 24, and 150. Any necessary control/regulation signal such as on line 42 is fed back from the load (functional card) to the power supply via conventional connectors or via a small signal version of the flux link connectors described above.

A direct approach toward implementing a minimum ripple coupled output filter inductor in accordance with the general teachings of US-A-4,703,409 is to place all windings around a common flux path. The induced voltage requirement for the zero-ripple windings is satisfied by adjusting the number of turns in the windings. The component physically resembles a conventional transformer and uses standard bobbins and cores.

However, in such case, the length of any turn in any winding encircles the common core path, which must be large enough to handle the d.c. flux from the sum of all the amp-turns of all the windings. The resulting d.c. resistance of the winding can be a problem, particularly in high-current outputs. Further, discrete turns around a common core can present a nearest turn number problem, forcing acceptance of "nearly correct" induced voltage in the zero-ripple windings.

In principle, only the one winding with ripple must encircle the sum of the flux from all windings. Further, the induced voltage requirement for the zero-ripple windings can be satisfied with, in the limit, one turn per winding - provided that one turn encircles the required amount of a.c. flux from the one winding with ripple. Such considerations lead to a multiple path core geometry, as shown in Fig. 10. In the structure shown, the core 150 embraces the inductor windings 62, 64, 66 and 104, and is completed by magnetic gap filler inserts 180, 182, 184 carried by the movable winding structure 140. The simplicity of the zero-ripple windings and planar geometry of the multiple path core 15 makes this structure particularly attractive for multi-output supplies.

Fig. 11 shows schematically the operational relationships of the parts shown in Fig. 10. The ratios of the cross-sectional areas of the core portions, and thus the flux portions, linked by the windings, determine the relative contribution of the effect of the ripple bearing winding 104 on each of the ripple-free windings 62, 64, 66. The number of turns on the respective primaries 12, 14, 16 determines the voltages induced in the respective single

turn secondaries, and the ratios of the flux portions linked by the single turn inductors 62, 64, 66 correspond to the ratios of those induced voltages in accordance with the general teachings of the aforesaid U.S. Patent 4,703,409. The turns, voltages and core areas shown in the drawings illustrate quantitative relationships in a general way, but are not intended to be to scale.

The magnetic structures (transformers and inductors) illustrated in Fig. 4 perform the function of a high current power connector without any ohmic contact required. This arrangement involves inserting a tongue-like extension containing conductors (Fig. 5) or conductors and ferrite insert (Fig. 10) into a slot in the fixed ferrite cores.

The magnetic structure of Fig. 12 performs the same function; i.e., it is a transformer or inductor which serves as an electrical connector with no ohmic contact. However, the mechanical arrangement is simpler. As illustrated in Fig. 12, the lower half of the cores 20′, 22′, 24′, 150″ remain with the secondary structures 28, 30, 32, 62, 64, 66, and the associated diodes 56, 58, 60, 68, 70, 72 as part of the card structure 140′. The upper halves of the cores 20′, 22′, 24′, 150″ remain with their primary windings 12, 14, 16 as part of primary structure 120. When withdrawn, each ferrite portion is a block with flat mating surfaces and winding area, as shown in Fig. 12. The flat surfaces, mating in a lap joint, eliminate difficulties associates with constructing the ferrite core with a slot and aligning the tongue for insertion. Further, having exposed planar winding areas creates the potential for fabrication of conductors for windings, wiring, and interconnections by deposition or similar techniques with minimum assembly or stacking of conductor layers.

An alternate arrangement of Fig. 7 is shown in Fig. 13. Here, the rectifier chips or pellets 56, 68 are positioned on opposite sides of the core. The secondary structure 28′ consists of one conductor which connects the inductor bus to the top of the chips, and another conductor which connects to the bottom of the chips and forms the dc bus 170′. Together, these conductors provide a diode-diode conduction loop 164′ which has little deviation from the ideal planar loop represented by the primary winding 12, and thus this arrangement facilitates the commutating action of the diodes in the same manner as the arrangement in Fig. 7. Such placement of the chips may provide mechanical or cooling advantages compared to Fig. 7, but would be equivalent electrically.

The above described embodiments of the invention provide compact and efficient structures for coupling, magnetically and without electrical connection, a power source to a plurality of loads. While only selected embodiments have been described in detail, it will be apparent that the invention is not limited thereto but is defined by the appended claims.

Claims

1. A power system including a separable transformer assembly in which a card having a planar secondary winding of the transformer is detachably mounted thereon to provide power to the card by magnetic coupling without electrical contact, the card being inserted -mechanically but not electrically plugged - into complementary parts of the magnetic circuit of the transformer means, to complete the same.

2. A power system as claimed in claim 1, wherein the card carries planar windings magnetically coupled to a filter winding structurally associated with the primary winding of the power transformer.

3. A power system as claimed in either preceding claim, wherein the card carries plural output circuits, each having imposed on it an a.c. ripple voltage by the transformer means and including a driven filter inductor winding, of one turn, magnetically associated with a driving filter winding by a common magnetic core having a main portion carrying the driving winding and a plural magnetic flux path portion carrying the driven filter windings, with the cross-sectional areas of the paths being so related that single turn windings encircling one or more of the paths can have generated in them, by the flux they encircle, a.c. potentials which are a function of a.c. ripple current carried by the driving winding, but which differ between themselves in proportion to the differing ripple a.c. potentials imposed on them.

4. A power system as claimed in claim 3 where the power transformer comprises secondary circuit structures including planar rectifier and free-wheeling diode components within the secondary winding whereby inductance in the circuit loop formed by the secondary winding is reduced and commutating action of the diodes is facilitated.

5. A power system as claimed in any preceding claim and including plural power transformers and plural output filter inductor structures, primary and secondary portions of the power transformers, and driving and driven portions of the filter inductor structure having lap joint relationships to each other, formed into two pluggable assemblies.

6. A power system as claimed in claim 2 and providing plural d.c. output circuits, each the output circuit having imposed on it an a.c. ripple voltage and including a driven filter inductor winding of one turn magnetically associated with a driving filter winding by a common magnetic core having a

main portion carrying the driving winding and a plural magnetic flux path portion carrying the driven filter windings, with the cross-sectional areas of the paths being so related that single turn windings encircling one or more of the paths can have generated in them, by the flux they encircle, a.c. potentials which are a function of ripple current carried by the driving winding, but which differ between themselves in proportion to the differing ripple potentials imposed on them.

7. A power system as claimed in any preceding claim, wherein the secondary circuit structure includes planar rectifier and free-wheeling diode components within a secondary winding of the transformer whereby inductance in the circuit loop formed by the secondary winding is reduced and commutating action of the diodes is facilitated.

8. A power system as claimed in any preceding claim, wherein the card includes a ferromagnetic insert imbedded in the planar transformer secondary in position to complete the magnetic circuit when the card is inserted.

9. A power system as claimed in any preceding claim wherein, the mechanical coupling is essentially a tongue and groove structure.

10. A power system as claimed in any of claims 2 to 6 providing supply circuit for producing a plurality of outputs comprising:
a voltage source;
transformer means having primary input coil means connected to the voltage source and secondary output coil means;
output stage means of a first class connected to the secondary output coil means and including an inductor winding carrying ripple current; and
a plurality of output stages of a second class for providing a plurality of outputs, each of the plurality of output stages of the second class connected to the secondary coil means, each of the plurality of output stages of the second class including single turn inductor winding, each inductor winding of the second class being magnetically coupled to the inductor winding of the output stage means of the first class, the output coil means imposing proportionally related voltages on the output stages;
the inductor windings sharing a common core structure, the core structure defining multiple flux paths linked by the windings of the second class, cross-sectional areas of the flux paths being chosen such that the induced open-circuit voltages across each inductor included in the output stages of the second class (when the inductors included in the plurality of output stages of the second class are disconnected from their respective output stages) are approximately identical to the imposed operating voltages thereon when the inductors included in the plurality of output stages of the second class are connected to their respective output stages;
the ripple current through the inductors included in the plurality of output stages of the second class being much lower than the ripple current in the inductor means of the first class.

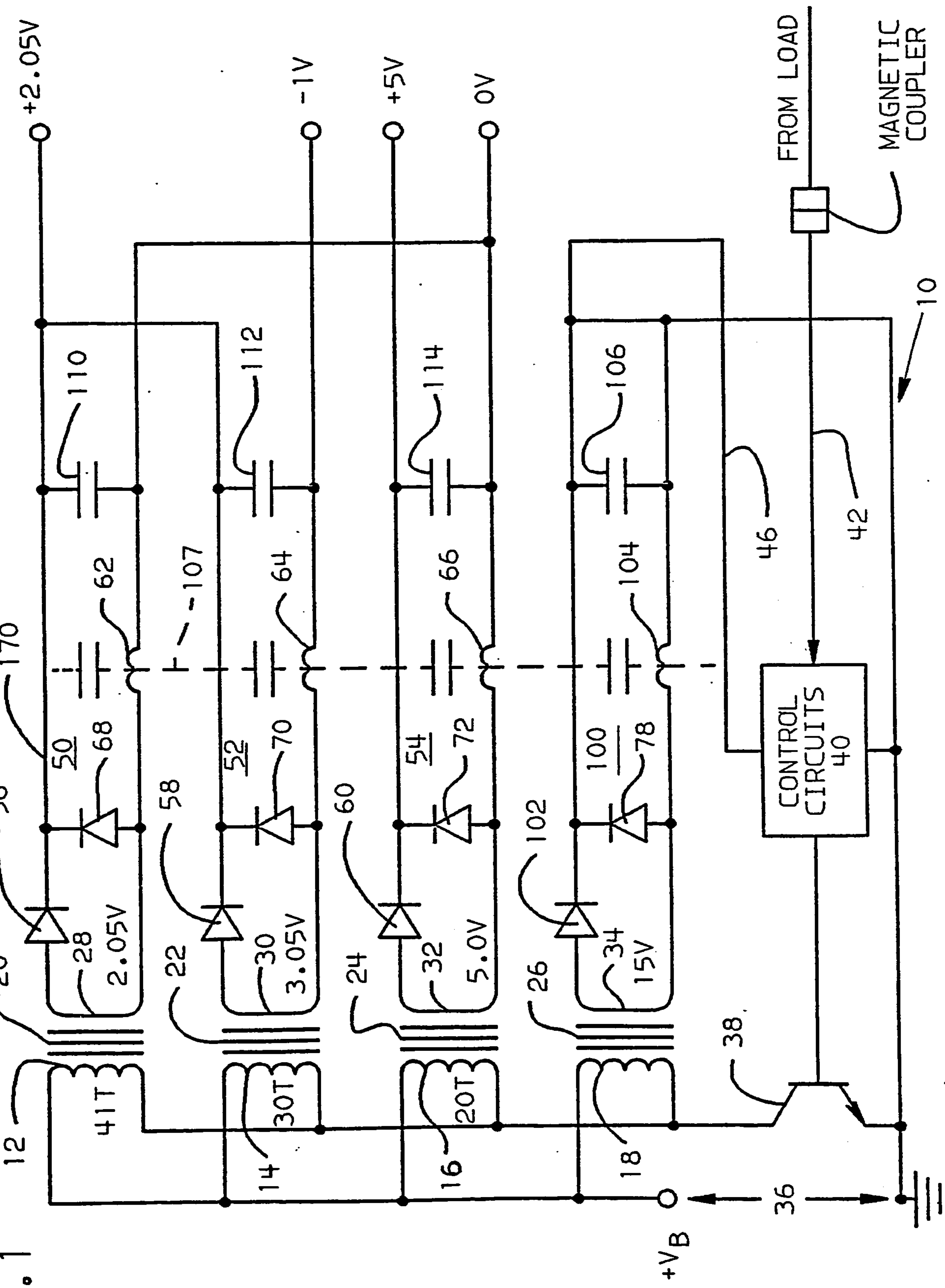

+2.05V
-1V
+5V
0V
FROM LOAD
MAGNETIC COUPLER
10
110
112
114
106
46
42
62
107
64
66
104
170
50
52
54
100
68
70
72
78
56
58
60
102
CONTROL CIRCUITS 40
20
28
2.05V
22
30
3.05V
24
32
5.0V
26
34
15V
38
12
41T
14
30T
16
20T
18
+V_B
36

FIG. 1

FIG. 2

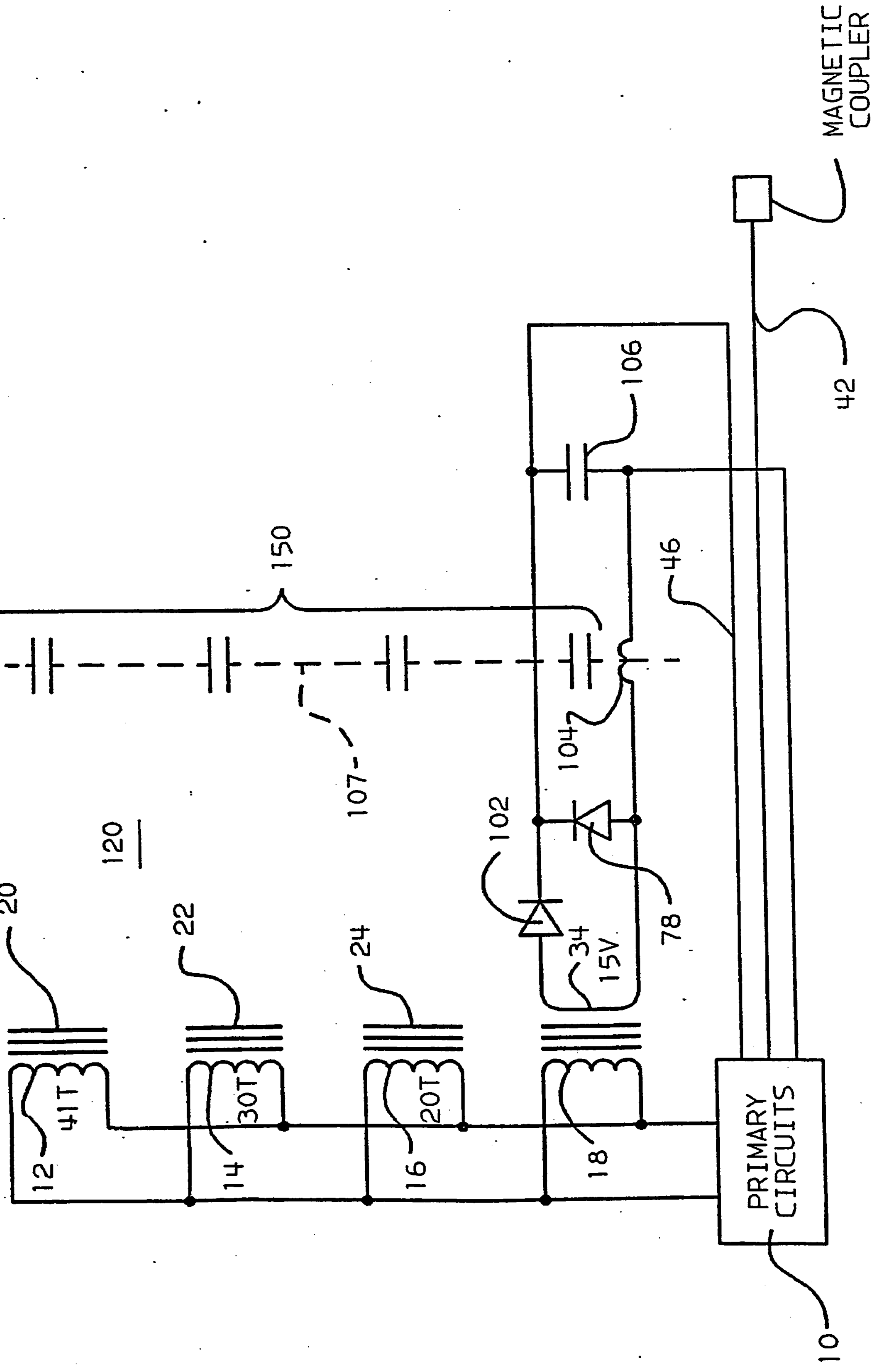
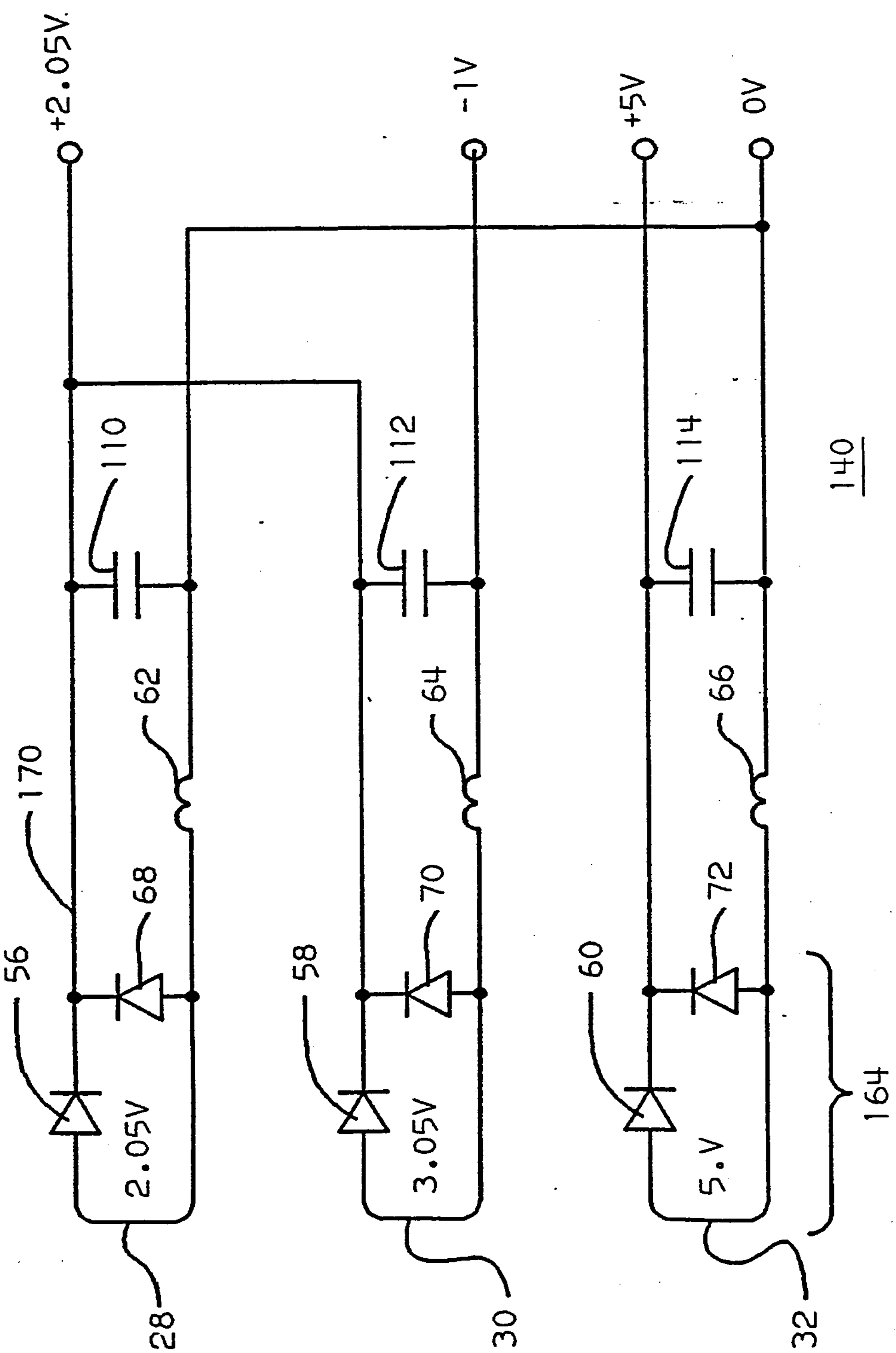

MAGNETIC COUPLER
PRIMARY CIRCUITS
41T
30T
20T
15V
10
12
14
16
18
20
22
24
34
42
46
78
102
104
106
107
120
150

FIG. 3


+2.05V
-1V
+5V
0V
110
112
114
140
170
62
64
66
56
68
58
70
60
72
2.05V
3.05V
5.V
164
28
30
32

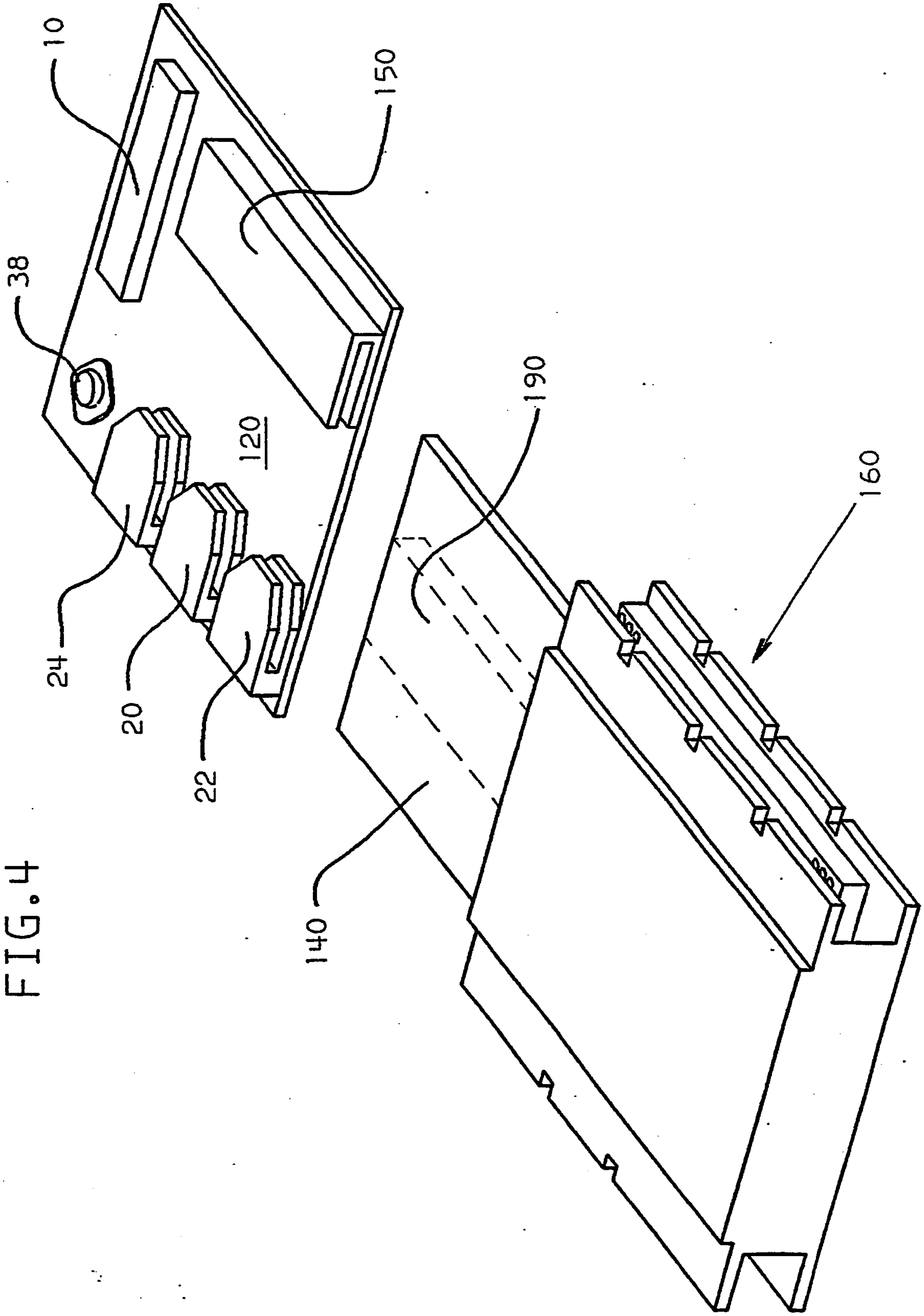


FIG.4

FIG.5

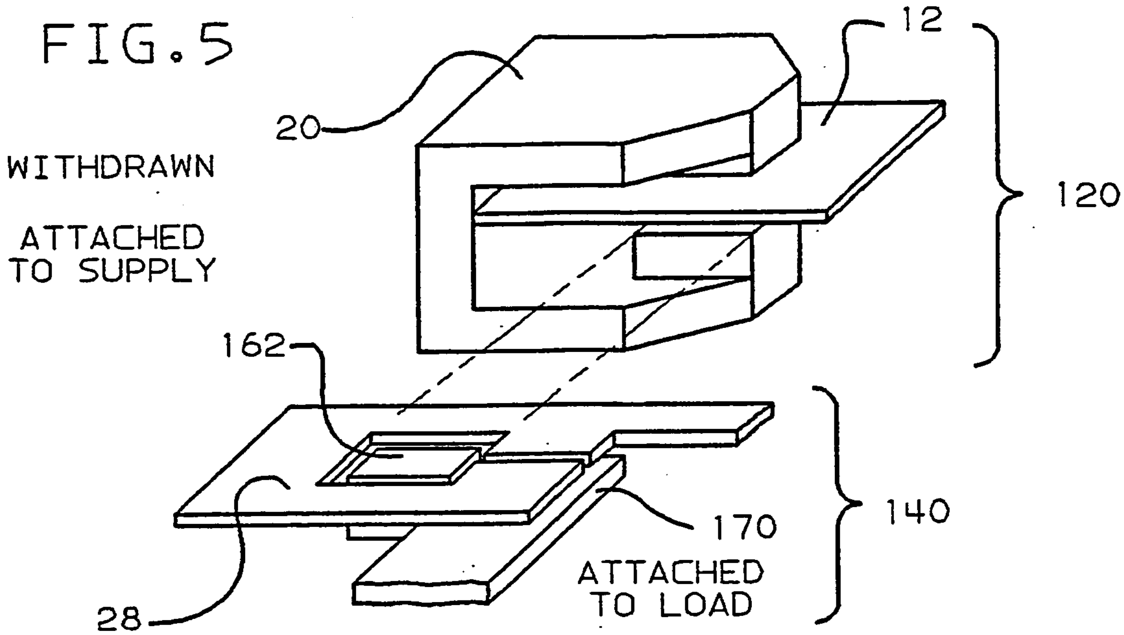


FIG.6

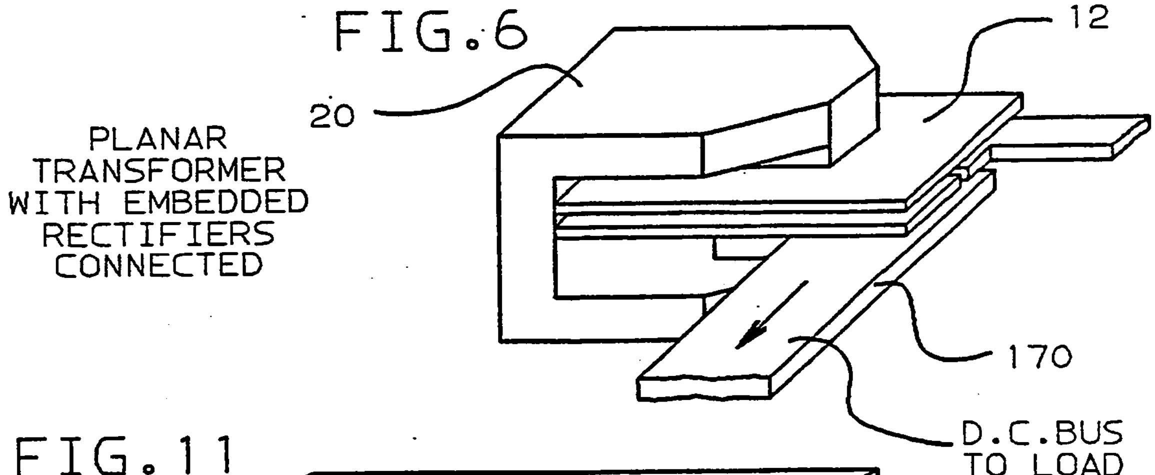


FIG.11

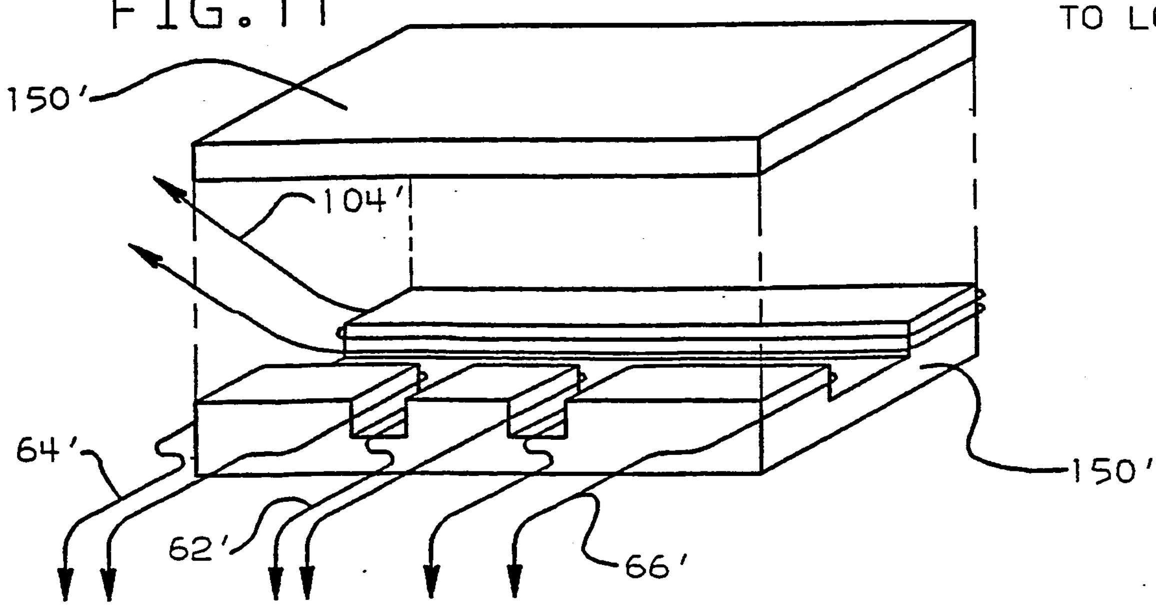


FIG. 7

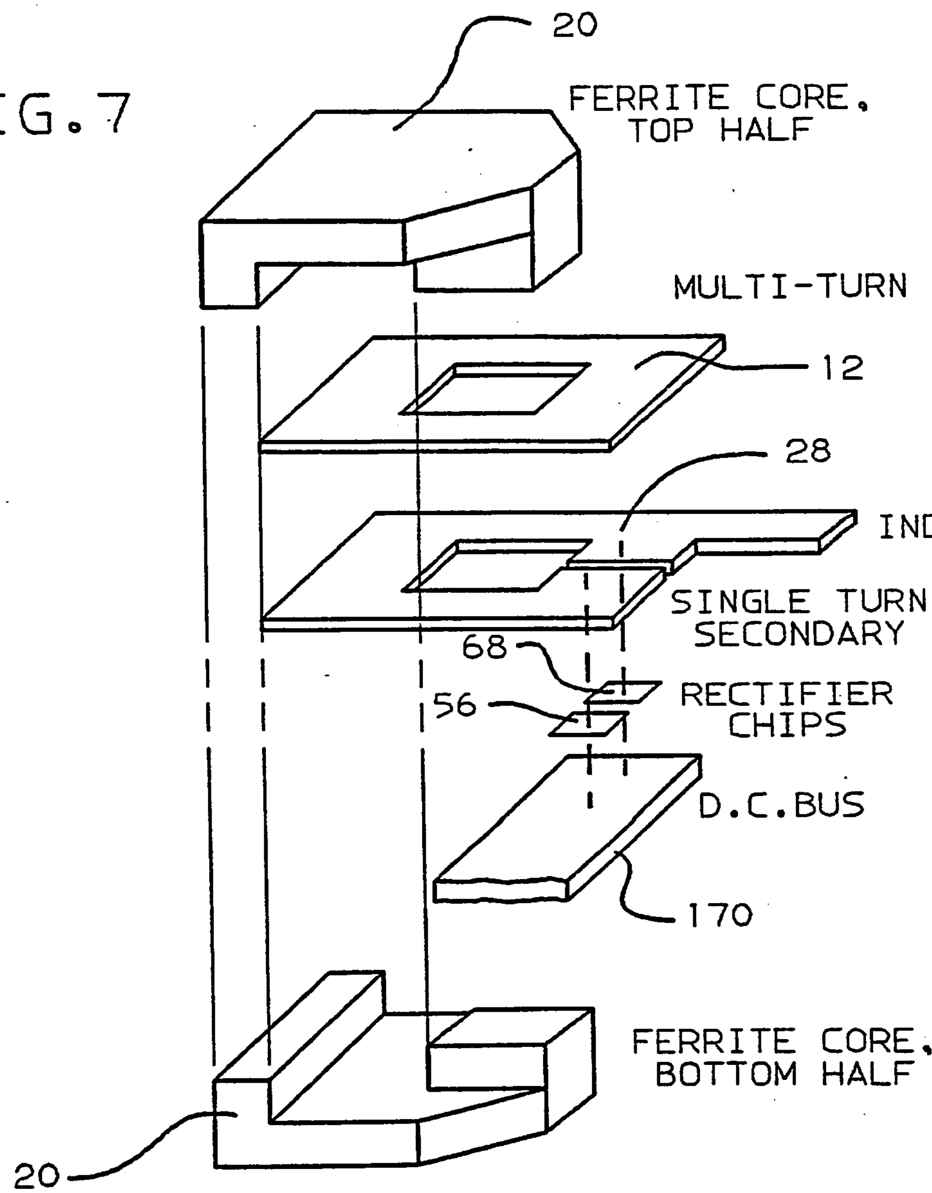

20
FERRITE CORE,
TOP HALF
MULTI-TURN PRIMARY
12
28
TO
INDUCTOR
SINGLE TURN
SECONDARY
68
RECTIFIER
CHIPS
56
D.C. BUS
170
FERRITE CORE,
BOTTOM HALF
20

FIG. 8

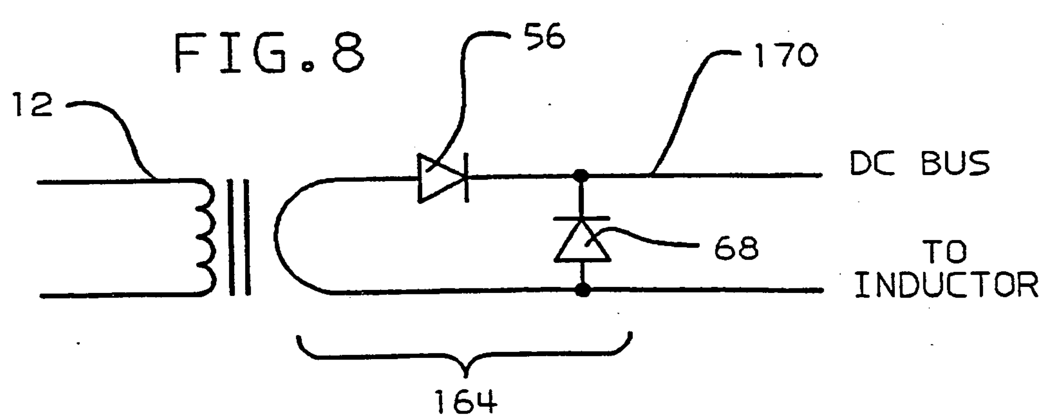

56
170
12
DC BUS
68
TO
INDUCTOR
164

FIG.9

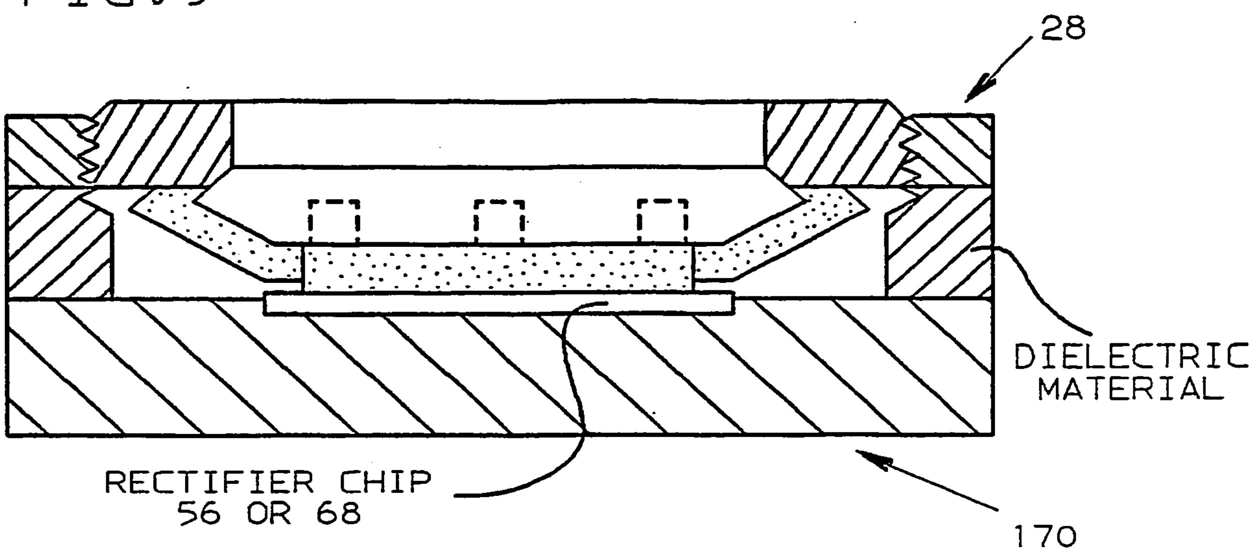
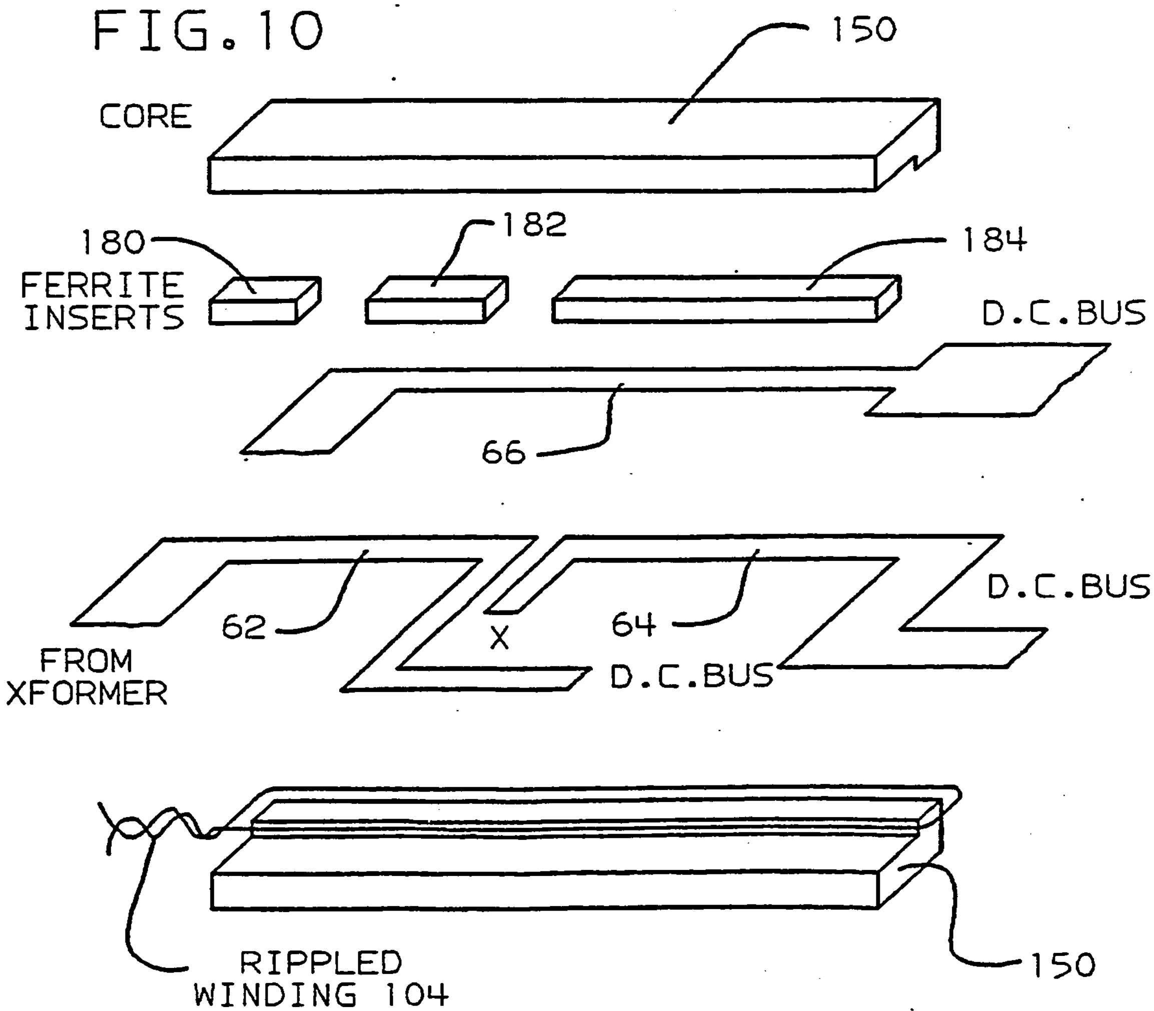

28
DIELECTRIC MATERIAL
RECTIFIER CHIP 56 OR 68
170

FIG.10


150
CORE
180
182
184
FERRITE INSERTS
D.C.BUS
66
62
X
64
D.C.BUS
FROM XFORMER
D.C.BUS
RIPPLED WINDING 104
150

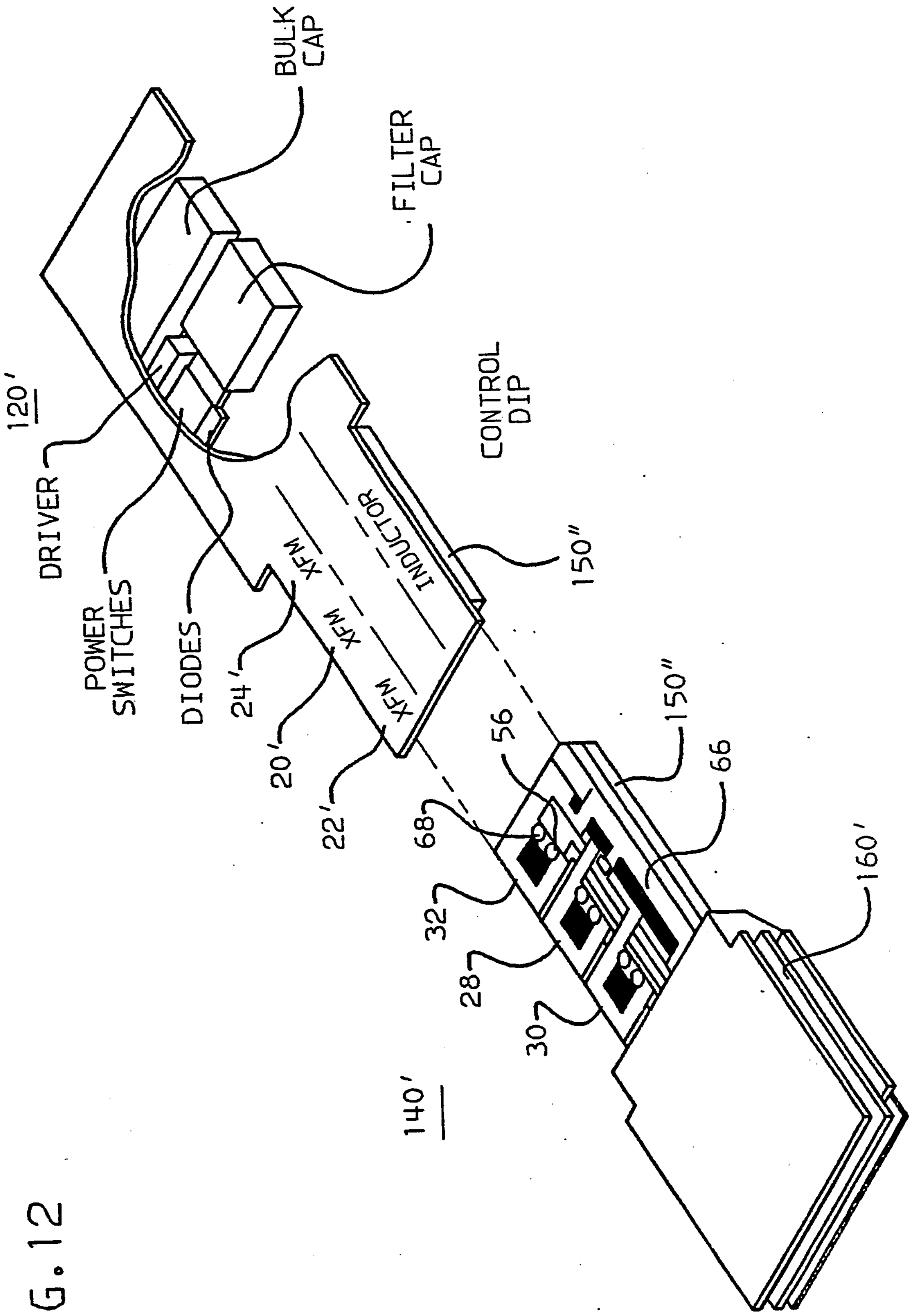
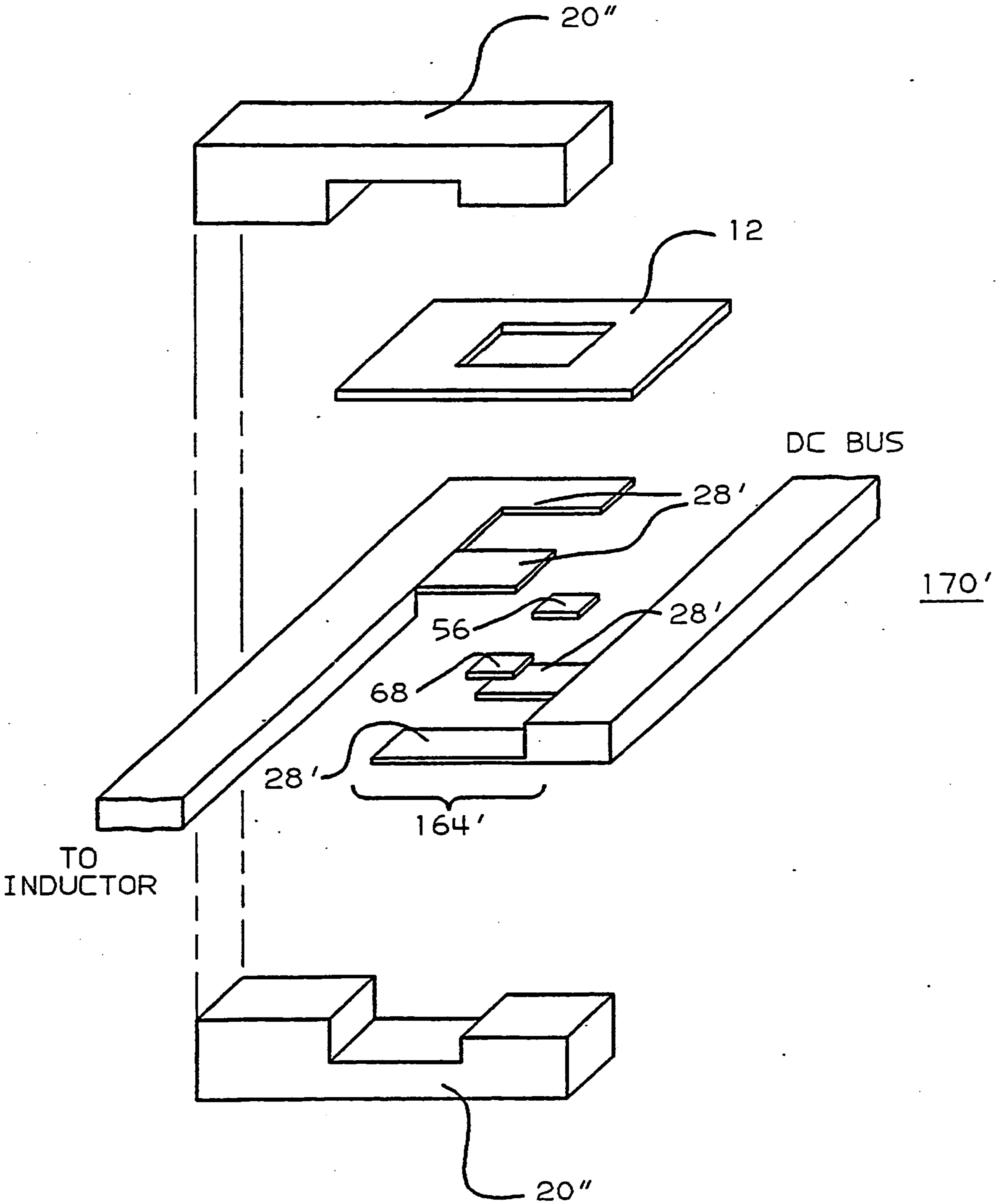

BULK CAP
FILTER CAP
CONTROL DIP
120'
DRIVER
POWER SWITCHES
DIODES
24'
20'
22'
XFM
XFM
XFM
INDUCTOR
150"
150"
56
68
32
28
30
66
160'
140'

FIG.12

FIG. 13



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 30 8584

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 82 (E-392)[2139], 2nd April 1986; & JP-A-60 227 406 (NIHON ESU ESU AI KAADO K.K.) 12-11-1985 * Whole document * ---	1	H 01 F 23/00 H 02 M 1/14
D,A	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 17, no. 2, July 1974, pages 492,493; P. ABRAMSON et al.: "Security device power source" * Page 493, paragraphs 4-6 * ---	1,8	
A	PATENT ABSTRACTS OF JAPAN, vol. 5, no. 15 (E-43)[687], 29th January 1981; & JP-A-55 144 775 (TOKYO DENKI KAGAKU KOGYO K.K.) 11-11-1980 * Whole document * ---	3-7,10	
A	US-A-1 870 625 (THE PYLE-NATIONAL CO.) * Page 1, lines 87-94 * ---	9	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
D,A	EP-A-0 139 870 (IBM CORP.) ---		
A	US-A-4 471 423 (A.M. HASE) ---		H 01 F 23/00 H 02 M 1/00
A	US-A-3 916 286 (UNITED TECHNOLOGIES CORP.) ---		
A	PATENT ABSTRACTS OF JAPAN, vol. 5, no. 15 (E-43)[687], 29th January 1981; & JP-A-55 144 776 (USAC DENSHI KOGYO K.K.) 11-11-1980 ---		
A	US-A-4 605 268 (NL INDUSTRIES) -----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-01-1989	VANHULLE R.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)